US007827314B2

(12) **United States Patent**
Gibbs et al.

(10) **Patent No.: US 7,827,314 B2**
(45) **Date of Patent: *Nov. 2, 2010**

(54) **DEVICE SPECIFIC PAGINATION OF DYNAMICALLY RENDERED DATA**

(75) Inventors: **Matthew E. Gibbs**, Redmond, WA (US); **Shanku S. Niyogi**, Bellevue, WA (US); **Greg D. Schechter**, Seattle, WA (US); **Kristen Nilsen Nye**, Duvall, WA (US)

(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 970 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/620,327**

(22) Filed: **Jan. 5, 2007**

(65) **Prior Publication Data**

US 2007/0113179 A1 May 17, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/172,938, filed on Jun. 17, 2002, now Pat. No. 7,441,047.

(51) **Int. Cl.**
G06F 15/16 (2006.01)

(52) **U.S. Cl.** **709/247**; 715/251

(58) **Field of Classification Search** 709/200, 709/224, 232, 236, 247; 715/249–254
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,430,624 B1 8/2002 Jamtgaard et al.
7,305,114 B2 * 12/2007 Wolff et al. 382/141

(Continued)

OTHER PUBLICATIONS

Wei-Ying Ma, et al., "Framework for Adaptive Content Delivery in Heterogeneous Network Environments", Proceedings of SPIE—vol. 3969; Multimedia Computing and Networking 2000, Klara Nahrstedt, Wu-chi Feng, Editors; Dec. 1999.

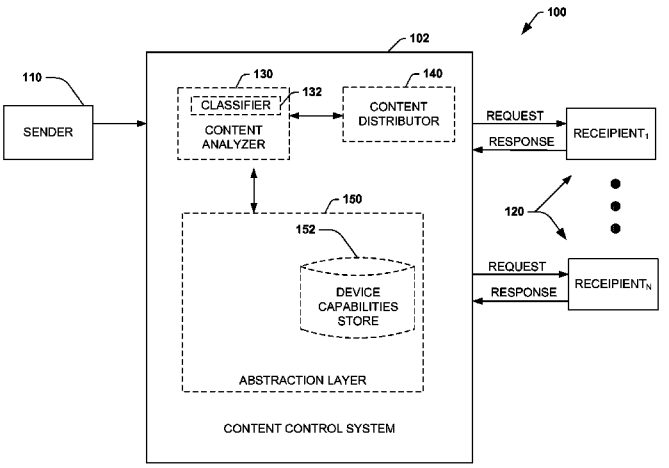
(Continued)

Primary Examiner—Moustafa M Meky
(74) *Attorney, Agent, or Firm*—Workman Nydegger

(57) **ABSTRACT**

The present invention relates to a system and methodology that provides for adjusting content that is to be received and displayed by a device so that the content is meaningful to a recipient. The invention provides for rendering of variable-sized pages of dynamic content based at least in part on user interface (UI) characteristics of a receiving device (e.g., client program). One particular aspect of the invention provides for an abstraction layer that permits a content developer to specify what content is to be displayed to an end user without requiring the developer to delineate markup tags that are to be employed by different browsers of respective mobile devices. Thus, for example, such aspect of the invention provides for automatically adjusting (e.g., paginating) content into variable-sized pages appropriate for a requesting device. A content analyzer receives and analyzes content to be rendered at a plurality of recipient devices against display capabilities of the respective devices. An abstraction layer accesses information relating to capabilities of the devices, and maps attributes relating to the content to the device capabilities, the abstraction layer provides the mapping to the content analyzer. A content distributor parses the content into subsets coincident with the display capabilities of the respective devices, and sequentially distributes respective subsets to the devices for rendering thereof.

19 Claims, 12 Drawing Sheets



U.S. PATENT DOCUMENTS

7,441,047	B2 *	10/2008	Gibbs et al.	709/248
2002/0059367	A1	5/2002	Romero et al.	
2002/0116534	A1	8/2002	Teeple	
2002/0129016	A1	9/2002	Christfort et al.	
2003/0110234	A1	6/2003	Egli et al.	

OTHER PUBLICATIONS

J. Gonzalez, et al., "Optimizing Web Newspaper Layout using Simulated Annealing" 1999; pp. 1-10.

* cited by examiner

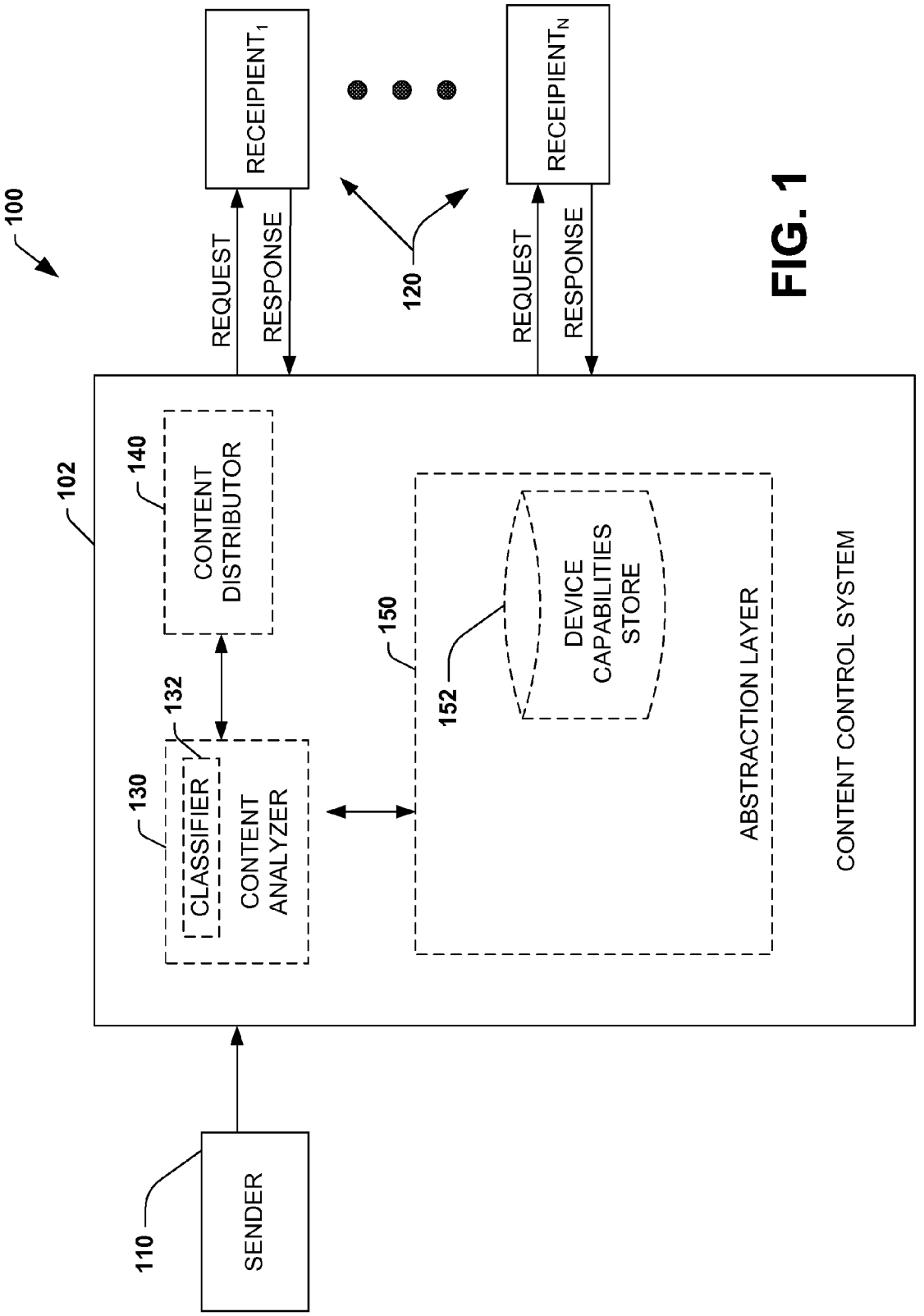
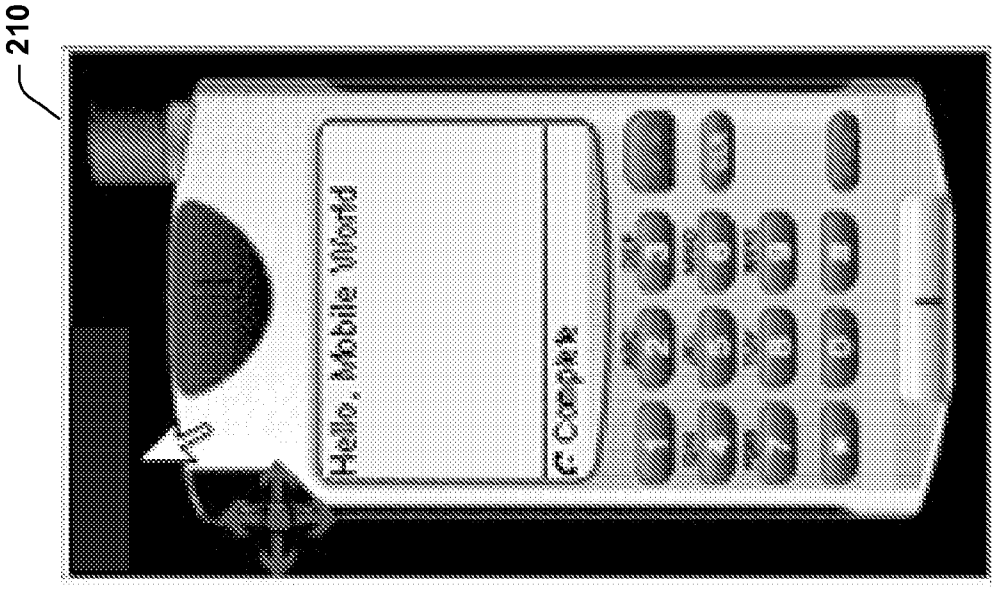

100
RECEIPIENT$_1$
RECEIPIENT$_N$
REQUEST
RESPONSE
120
REQUEST
RESPONSE
102
140
CONTENT DISTRIBUTOR
132
130
CLASSIFIER
CONTENT ANALYZER
150
152
DEVICE CAPABILITIES STORE
ABSTRACTION LAYER
CONTENT CONTROL SYSTEM
110
SENDER

FIG. 1


210
Hello, Mobile World
Accept

220
11:34
Hello, Mobile World
View Tools

FIG. 2

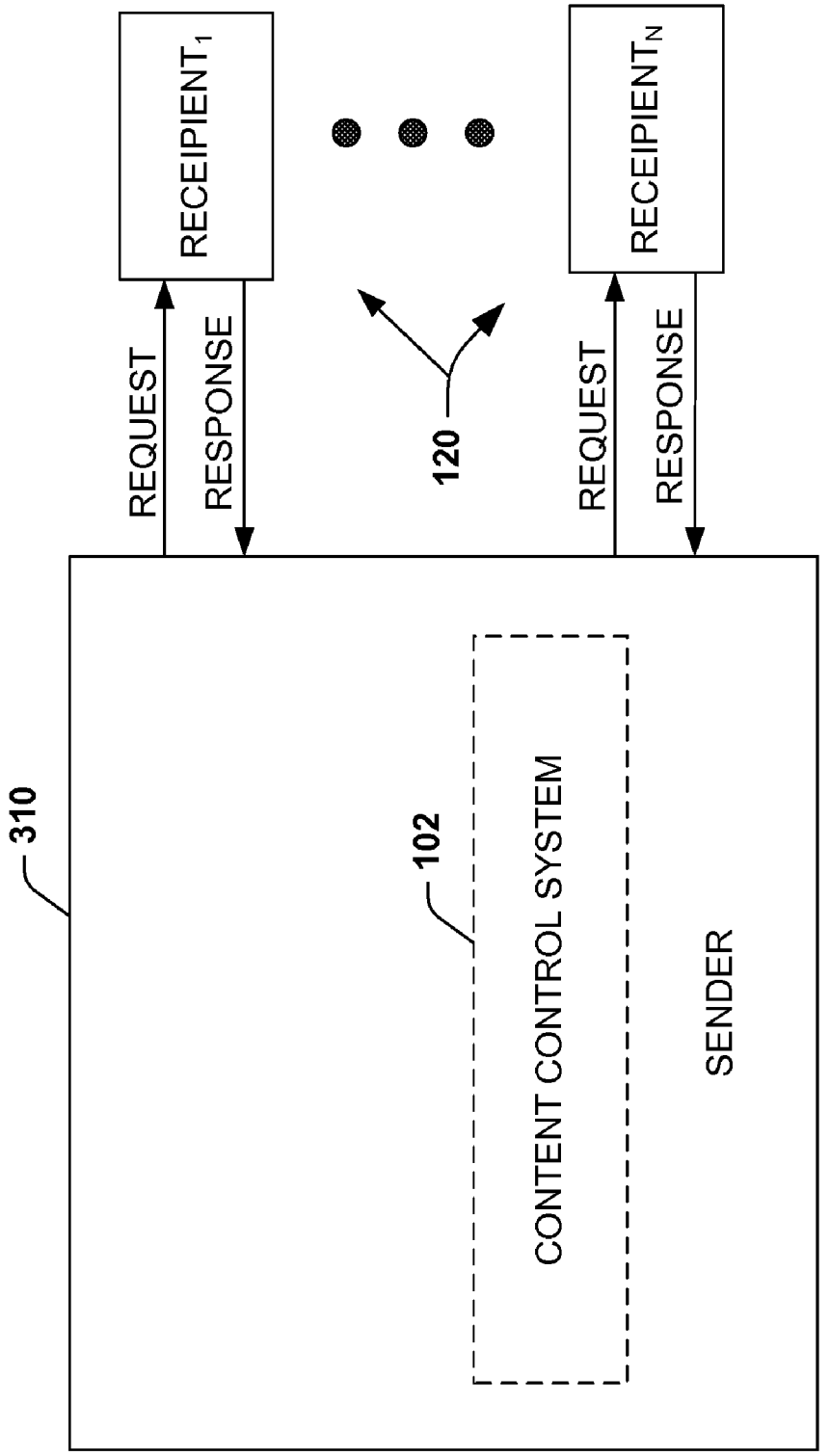

RECEIPIENT1
RECEIPIENTN
REQUEST
RESPONSE
REQUEST
RESPONSE
120
310
102
CONTENT CONTROL SYSTEM
SENDER

FIG. 3

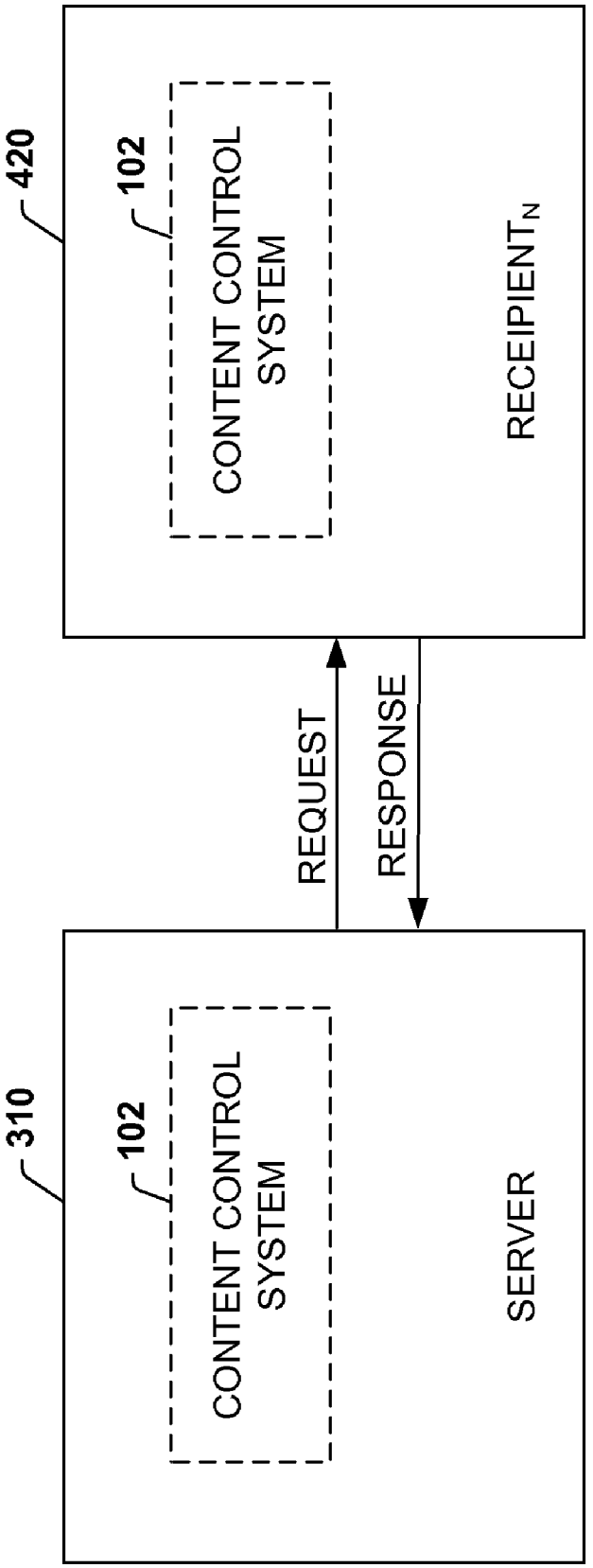

420
102
CONTENT CONTROL SYSTEM
RECEIPIENT$_N$
REQUEST
RESPONSE
310
102
CONTENT CONTROL SYSTEM
SERVER

FIG. 4

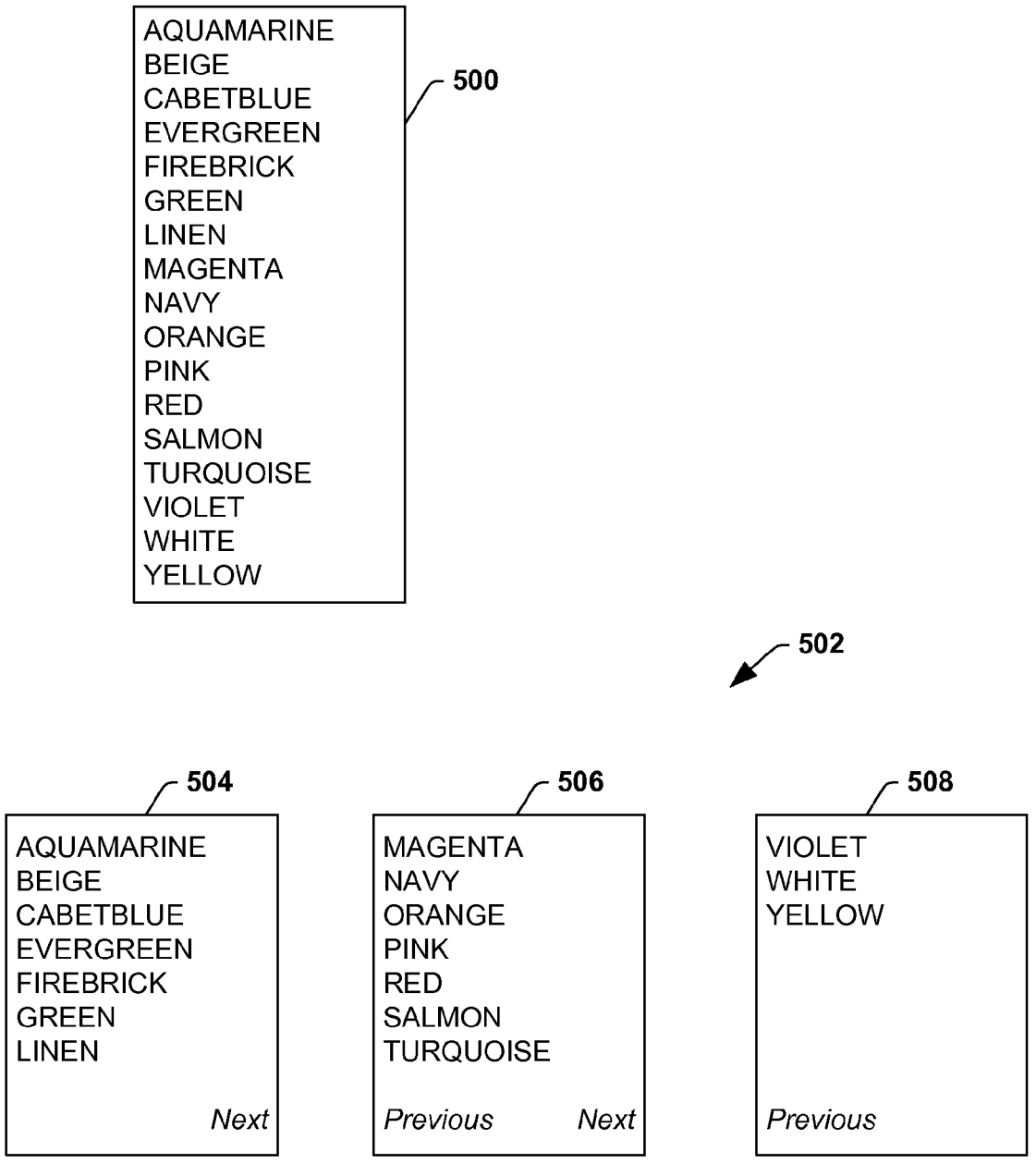

AQUAMARINE
BEIGE
CABETBLUE
EVERGREEN
FIREBRICK
GREEN
LINEN
MAGENTA
NAVY
ORANGE
PINK
RED
SALMON
TURQUOISE
VIOLET
WHITE
YELLOW
500
502
504
AQUAMARINE
BEIGE
CABETBLUE
EVERGREEN
FIREBRICK
GREEN
LINEN
Next
506
MAGENTA
NAVY
ORANGE
PINK
RED
SALMON
TURQUOISE
Previous
Next
508
VIOLET
WHITE
YELLOW
Previous

FIG. 5

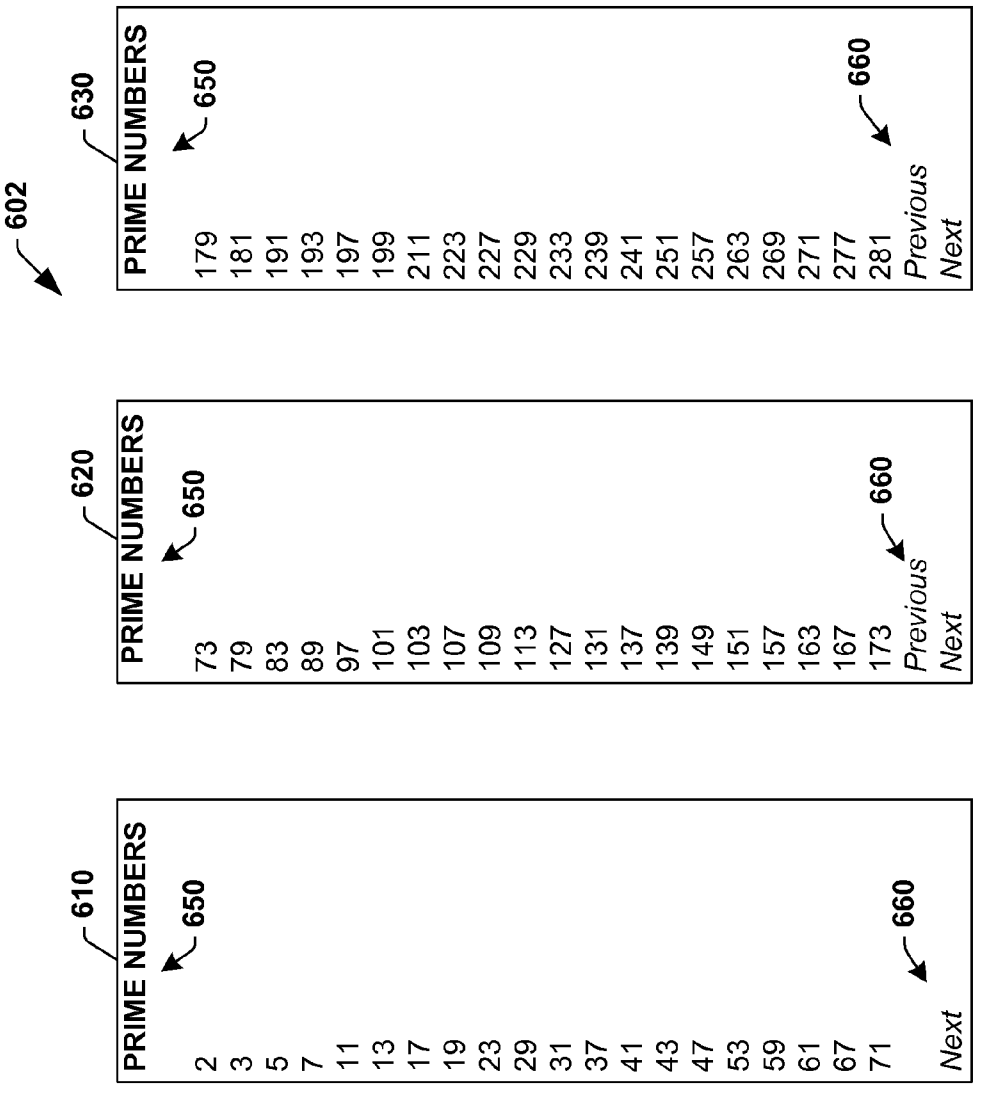

602
610
PRIME NUMBERS
650
2
3
5
7
11
13
17
19
23
29
31
37
41
43
47
53
59
61
67
71
660
Next
620
PRIME NUMBERS
650
73
79
83
89
97
101
103
107
109
113
127
131
137
139
149
151
157
163
167
173
660
Previous
Next
630
PRIME NUMBERS
650
179
181
191
193
197
199
211
223
227
229
233
239
241
251
257
263
269
271
277
281
660
Previous
Next

FIG. 6

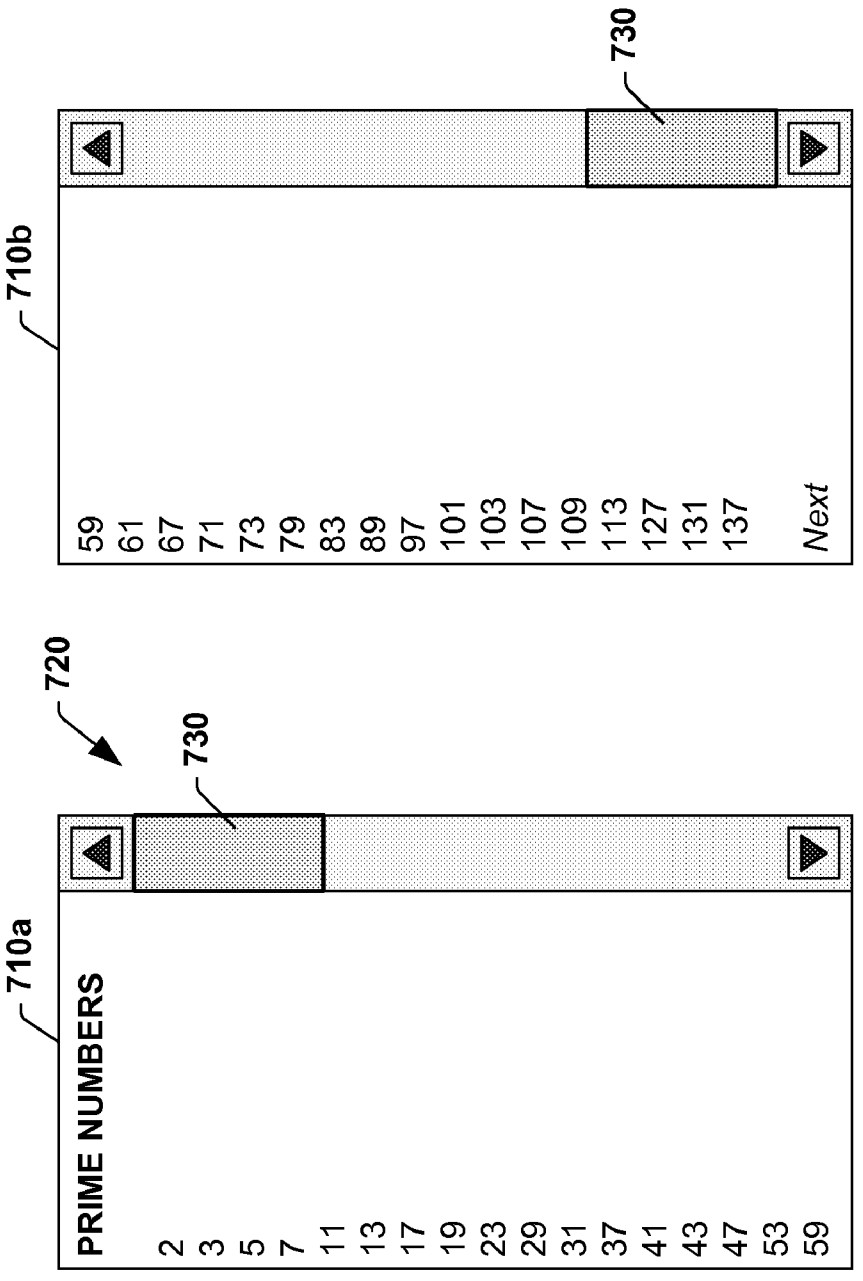

710a
720
730
PRIME NUMBERS
2
3
5
7
11
13
17
19
23
29
31
37
41
43
47
53
59
710b
730
59
61
67
71
73
79
83
89
97
101
103
107
109
113
127
131
137
Next

FIG. 7

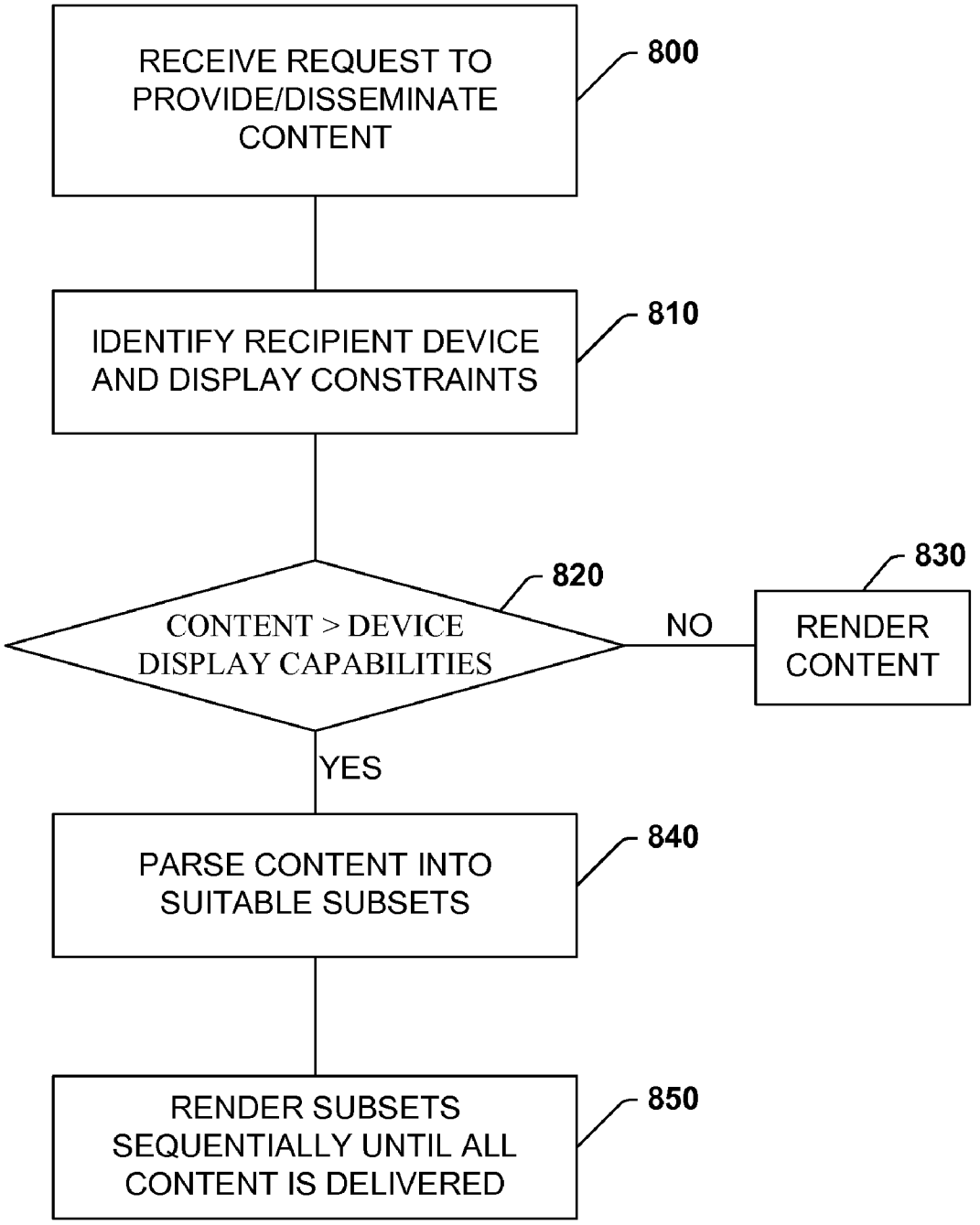

RECEIVE REQUEST TO PROVIDE/DISSEMINATE CONTENT
800
IDENTIFY RECIPIENT DEVICE AND DISPLAY CONSTRAINTS
810
CONTENT > DEVICE DISPLAY CAPABILITIES
820
NO
RENDER CONTENT
830
YES
PARSE CONTENT INTO SUITABLE SUBSETS
840
RENDER SUBSETS SEQUENTIALLY UNTIL ALL CONTENT IS DELIVERED
850

FIG. 8

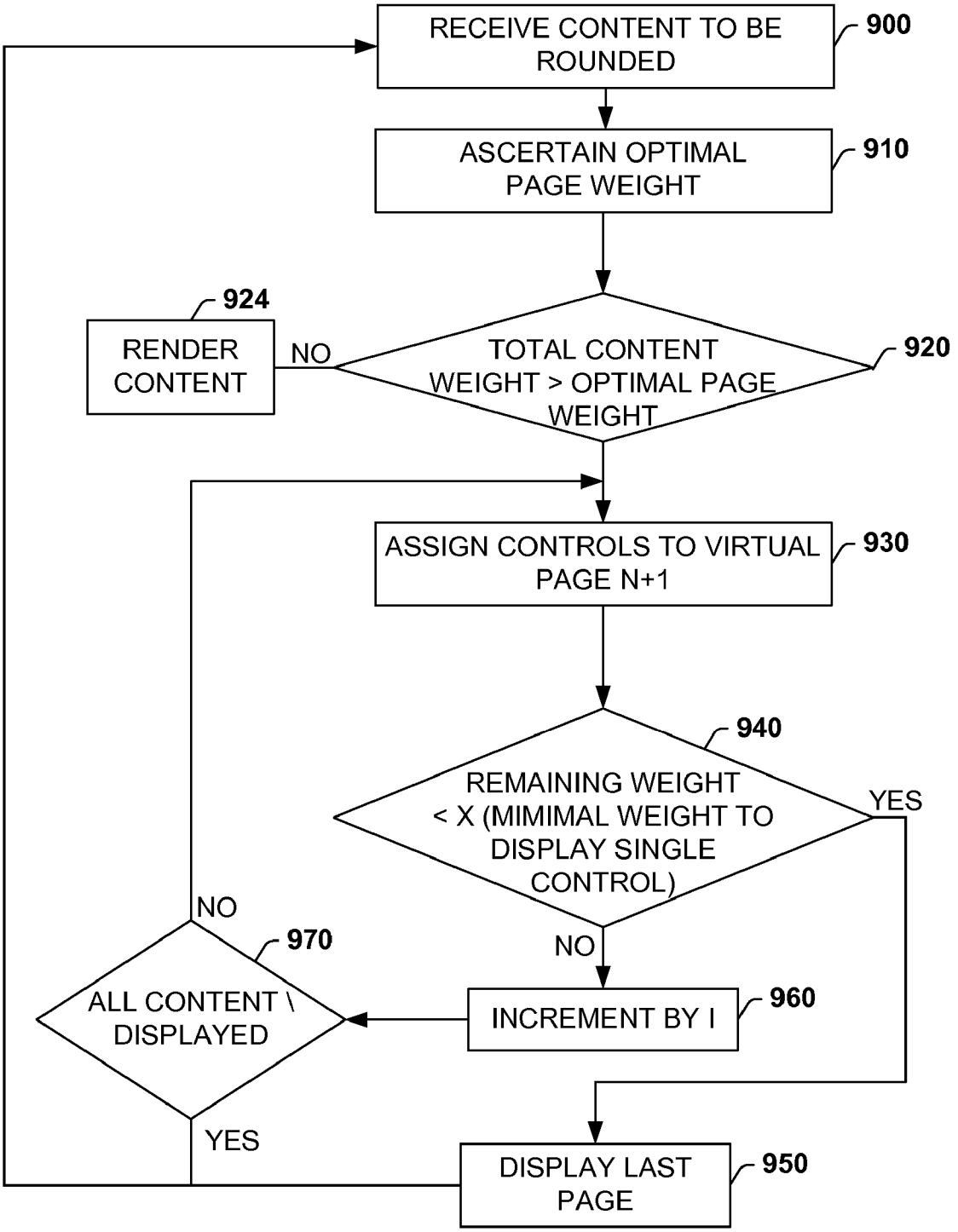

RECEIVE CONTENT TO BE ROUNDED
900
ASCERTAIN OPTIMAL PAGE WEIGHT
910
TOTAL CONTENT WEIGHT > OPTIMAL PAGE WEIGHT
920
NO
RENDER CONTENT
924
ASSIGN CONTROLS TO VIRTUAL PAGE N+1
930
REMAINING WEIGHT < X (MIMIMAL WEIGHT TO DISPLAY SINGLE CONTROL)
940
YES
NO
INCREMENT BY I
960
ALL CONTENT \ DISPLAYED
970
NO
YES
DISPLAY LAST PAGE
950

FIG. 9

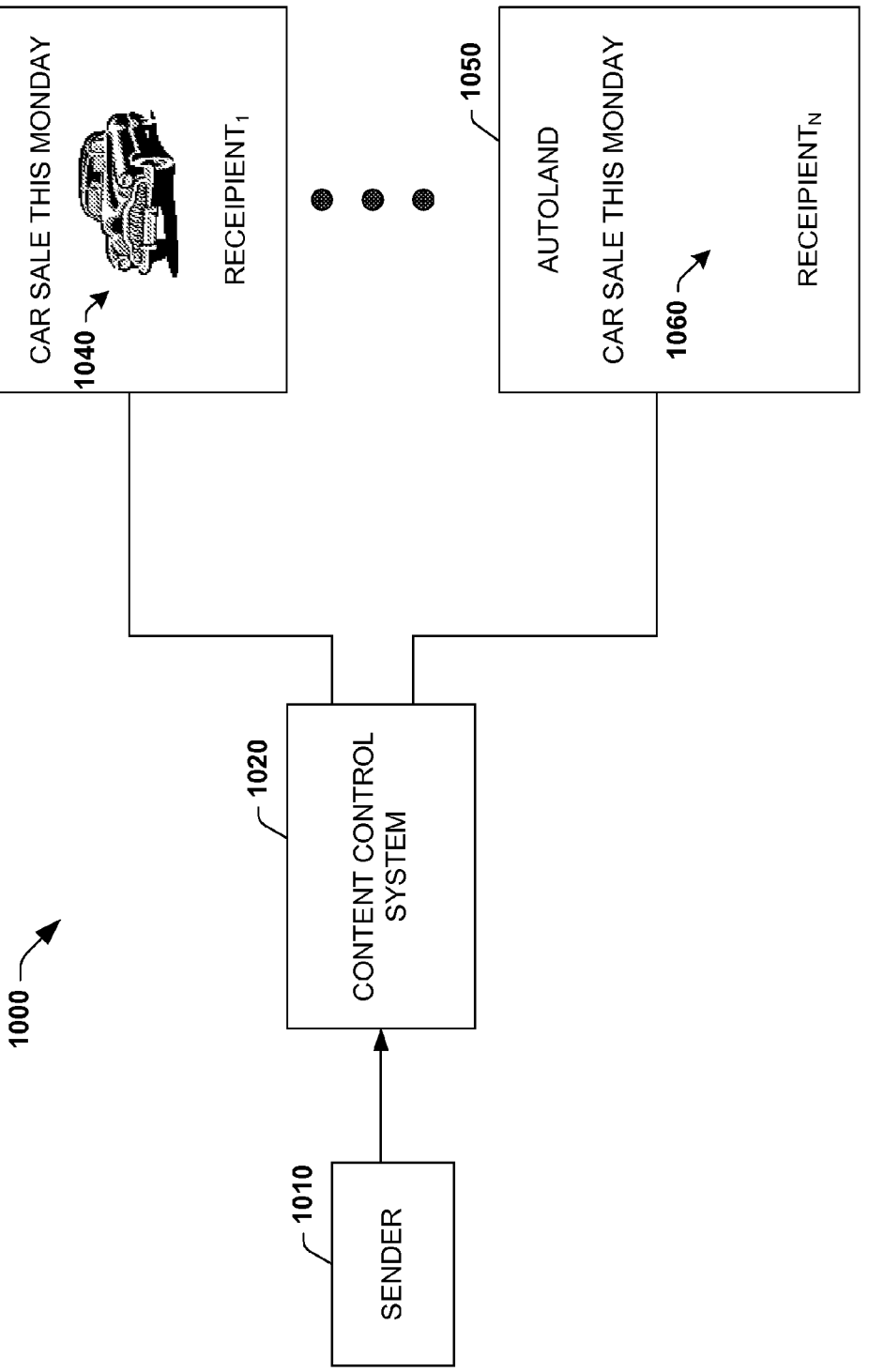

1000
SENDER
1010
CONTENT CONTROL SYSTEM
1020
AUTOLAND
CAR SALE THIS MONDAY
1030
1040
RECEIPIENT1
AUTOLAND
CAR SALE THIS MONDAY
1050
1060
RECEIPIENTN

FIG.10

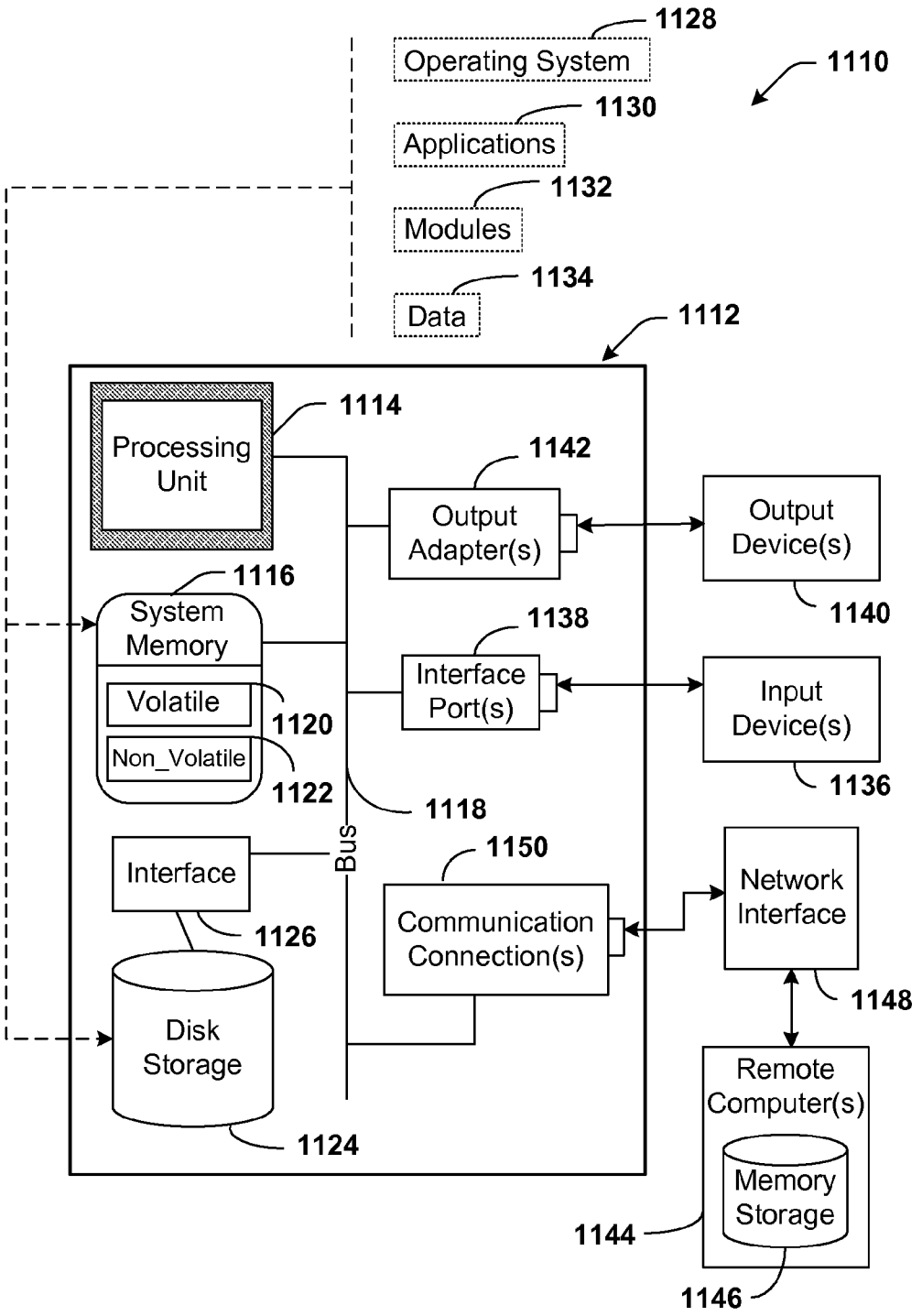

1128
Operating System
1110
1130
Applications
1132
Modules
1134
Data
1112
1114
Processing Unit
1142
Output Adapter(s)
Output Device(s)
1140
1116
System Memory
Volatile
1120
Non_Volatile
1122
1138
Interface Port(s)
Input Device(s)
1136
1118
Bus
Interface
1126
1150
Communication Connection(s)
Network Interface
1148
Disk Storage
1124
Remote Computer(s)
Memory Storage
1144
1146

FIG. 11

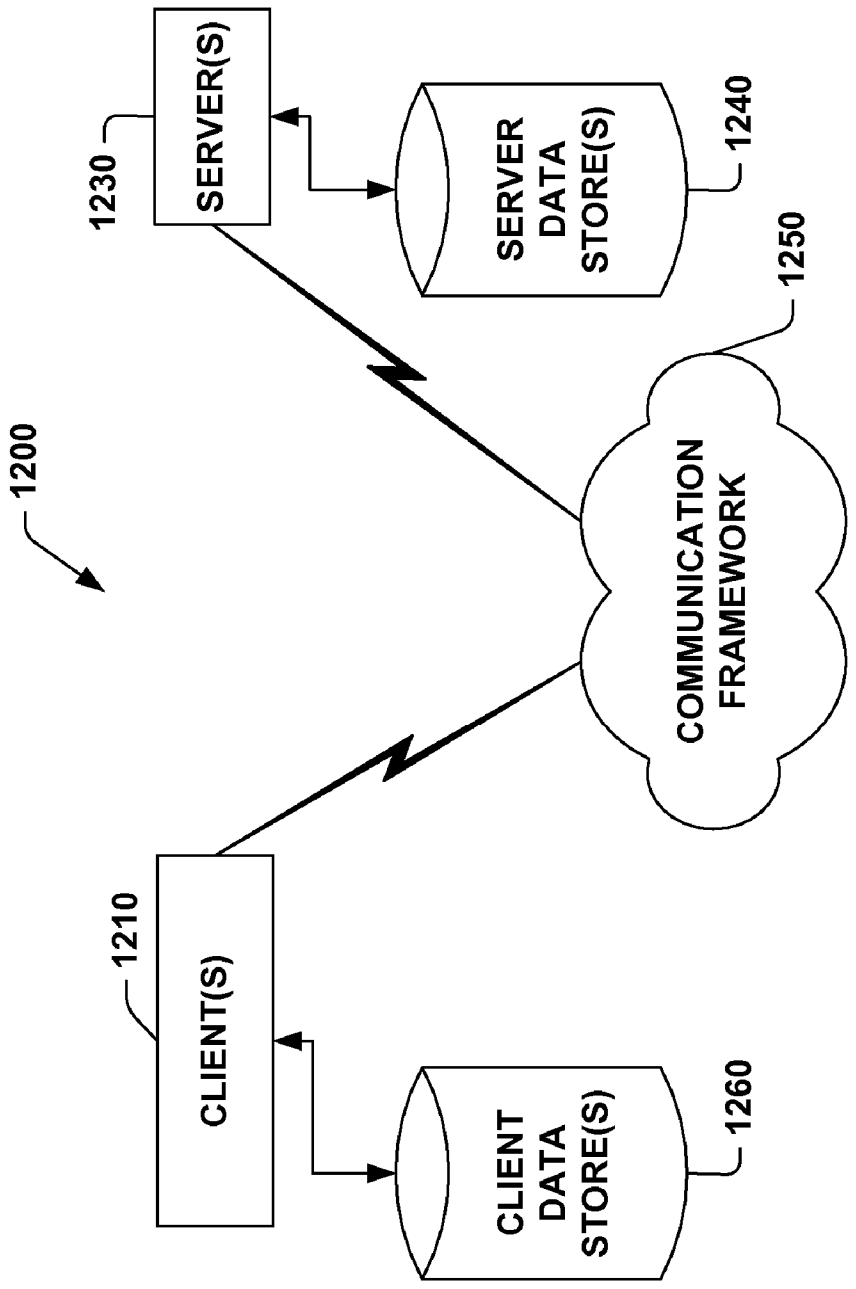

1200
SERVER(S)
1230
SERVER DATA STORE(S)
1240
1250
COMMUNICATION FRAMEWORK
CLIENT(S)
1210
CLIENT DATA STORE(S)
1260

FIG. 12

DEVICE SPECIFIC PAGINATION OF DYNAMICALLY RENDERED DATA

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 10/172,938, filed on Jun. 17, 2002, entitled "DEVICE SPECIFIC PAGINATION OF DYNAMICALLY RENDERED DATA", the entirety of which is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates generally to computer systems, and more particularly to a system and method providing information in a manner coincident with capabilities of a receiving device and/or preferences of a recipient.

BACKGROUND OF THE INVENTION

With the growth of computer and information systems, and related network technologies such as wireless and Internet communications, ever increasing amounts of electronic information are communicated, transferred and subsequently processed by users and/or systems. As an example, web browsers have become a popular application among computer users for generating and receiving content. With the advent of the Internet, for example, exchanging content (e.g., messages, files, web pages) has become an important factor influencing why many people acquire computers. However, with the heightened popularity of web browsers and other information transfer systems, problems have begun to appear with regards to managing, processing and rendering increasing amounts of content among a plurality of recipient device types.

The variety of devices that can access the internet includes not only traditional personal computers (PCs), but also cellular telephones, pocket organizers, auto PCs, etc. Many of such devices access the Internet through wireless networks and can be subjected to constraints with respect to the amount of data that can be transmitted to the device for display on a single page. As market forces continue to drive an ever increasing demand for portable computing devices and foster an environment for introducing new devices into the marketplace, the matrix of device display capabilities will continue to increase. Consequently, rendering content in a meaningful manner across a spectrum of differing devices becomes increasingly challenging. Moreover, markup language (e.g., hypertext markup language (HTML), compact hypertext markup language (cHTML), wireless markup language (WML), handheld wireless markup language (HDML)) capabilities as well as processing power with respect to the plurality of portable computing devices add to the complexity of data rendering among disparate and differing types of receiving devices.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is intended to neither identify key or critical elements of the invention nor delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

The present invention relates to a system and methodology that provides for adjusting content that is to be received and displayed by a device so that the content is meaningful to a recipient. The invention provides for rendering of variable-sized pages of dynamic content based at least in part on user interface (UI) characteristics of a receiving device (e.g., client program). One particular aspect of the invention provides for an abstraction layer that permits a content developer to specify what content is to be displayed to an end user without requiring the developer to delineate markup tags that are to be employed by different browsers of respective mobile devices. Thus, for example, such aspect of the invention provides for automatically adjusting (e.g., paginating) content into variable-sized pages appropriate for a requesting device.

The invention provides for a content provider/developer to simply specify basic constraints (e.g., grouping, headers, footers, adjustable content) regarding content provided, and the invention adjusts the content in accordance with such constraints as well as capabilities associated with recipient devices so that the content is presented in a meaningful manner. It is to be appreciated that devices not only vary with respect to UI capabilities but also with respect to processing capabilities. Accordingly, another aspect of the invention provides for controlling content delivery in accordance with such constraints. For example, one receiving device may have significant UI and processing capabilities and content can be rendered on such device with minor modifications, while another device with limited capabilities may lead to the invention modifying the content (e.g., trimming, chunking, paginating) in accordance with the respective device capabilities.

Moreover, a plurality of parameters can be configured in conjunction with various configuration and adjustment options to facilitate personalization of the user interface according to user desires. Personalization can include such features as employing explicit or implicit user feedback relating to how content is classified and subsequently provided to the user. Feedback can be employed to guide learning and decision policies with respect to rendering of content. Configuration and adjustment options can include profile options, routing options, alerting options, chunking options, schedule options, and other context-sensitive control options for controlling rendering of content. Additionally, the invention can employ default settings with respect to various types of recipient devices as well as employing an inference system to infer (given various uncertainties) how content should be rendered on a particular device. Various state information (e.g., time of day, type of content, recipient) can be employed in connection with decision making by the inference system in connection with meaningful rendering of content on recipient devices in accordance with the subject invention.

The following description and the annexed drawings set forth in detail certain illustrative aspects of the invention. These aspects are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic block diagram of a system employing content control in accordance with an aspect of the present invention.

FIG. **2** is a schematic block diagram of a content control system residing at a content originating device in accordance with an aspect of the present invention.

FIG. **3** is a schematic block diagram illustrating both content originator and content recipient running content control systems respectively in accordance with an aspect of the present invention.

FIG. **4** illustrates content being displayed on two different types of devices in accordance with the present invention.

FIG. **5** illustrates various content remaining static with respect to being displayed and other content being modifiable in accordance with the present invention.

FIG. **6** illustrates a device display that allows for scrolling of content as well as modifying of content in accordance with the present invention.

FIG. **7** is a diagram illustrating a high-level methodology in accordance with the present invention.

FIG. **8** is a diagram illustrating one particular methodology for modifying content in accordance with the present invention.

FIG. **9** is a schematic illustration of a content control system interoperating with various devices of differing capabilities in accordance with the present invention.

FIG. **10** is a schematic illustration of a system that manipulates content in connection with display and processing capabilities of a receiving device in accordance with an embodiment of the present invention.

FIG. **11** is a schematic block diagram of an exemplary operating environment for a system configured in accordance with the present invention.

FIG. **12** is a schematic block diagram of a sample-computing environment with which the present invention can interact.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It may be evident, however, that the present invention may be practiced without these specific details. In other instances, well-known structures and devices are shown in block diagram form in order to facilitate describing the present invention.

As used in this application, the terms "component" and "system" are intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers.

It is to be appreciated that, for purposes of the present invention, any or all of the functionality associated with modules, systems and/or components discussed herein can be achieved in any of a variety of ways (e.g. combination or individual implementations of active server pages (ASPs), common gateway interfaces (CGIs), application programming interfaces (API's), structured query language (SQL), component object model (COM), distributed COM (DCOM), system object model (SOM), distributed SOM (DSOM), ActiveX, common object request broker architecture (CORBA), database management systems (DBMSs), relational database management systems (RDBMSs), object-oriented database management system (ODBMSs), object-relational database management systems (ORDBMS), remote method invocation (RMI), C, C++, practical extraction and reporting language (PERL), applets, HTML, dynamic HTML, server side includes (SSIs), extensible markup language (XML), portable document format (PDF), wireless markup language (WML), standard generalized markup language (SGML), handheld device markup language (HDML), graphics interchange format (GIF), joint photographic experts group (JPEG), binary large object (BLOB), other script or executable components).

Referring initially to FIG. **1**, a system **100** in accordance with the present invention is illustrated. The system **100** provides for rendering of dynamically generated content in accordance with display and/or functional capabilities of a recipient device. A content originator **110** (sender) generates content that is to be rendered by one or more recipients **120** (RECIPIENT**1**-RECEIPIENTN, N being an integer). As can be appreciated, the recipients **120** can be of differing types and have capabilities that vary with respect to one another. For example, one of the recipient devices can be a cellular telephone with a limited amount of display real estate as well as processing capabilities, another recipient device could be a portable computer that is wireless enabled and have significant display capabilities as well as processing abilities. Yet another device (e.g., personal data assistant (PDA) could reside somewhere in between the aforementioned devices with respect to capabilities. However, one common thread with respect to these devices is that they are intended recipients of common content. The subject system **100** facilitates rendering such content in a meaningful manner and in accordance with capabilities associated with each respective recipient device **120**.

A content control system **102** receives the content that is to be disseminated and analyzes the content with respect to capabilities of the recipient devices **120**, and provides for proper rendering of the content by the recipient devices **120**. The content control system **102** includes a content analyzer **130** that analyzes the content with respect to device capabilities. Any suitable component for carrying out the functions of the content analyzer **130** may be employed and is intended to fall within the scope of the hereto appended claims. For example, the content analyzer **130** can employ a content classifier **132**, which can facilitate automatic classification of content. The classifier **132** can be trained explicitly and/or implicitly to perform classification in terms of dynamic rendering of content. Explicit training is generally conducted at the initial phases of constructing the classifier **132**, while implicit training is typically conducted after the classifier **132** has been constructed. Specific description is made herein with reference to a Support Vector Machines (SVM) classifier, for exemplary purposes of illustrating a classification training and implementation approach. Other classification or diagnostic methods that can be handcrafted and/or learned from data include Bayesian networks, decision trees, and probabilistic classification models providing different patterns of independence may be employed. Classification as used herein also is inclusive of statistical regression that is utilized to develop models of urgency or other measures of priority influencing content rendering.

According to one aspect of the invention, the use of the SVM method is employed as the classifier **132**. It is to be appreciated that other classifier models may also be utilized such as Naive Bayes, more general probabilistic dependency

models referred to as Bayesian networks, decision trees, and other learning models, including hierarchically structured versions of these models, where alternate layers employ the same or a different classifiers SVM's are configured via a learning or training phase within a classifier constructor and feature selection module **132**. A classifier is a function that maps an input attribute vector, x=(x1, x2, x3, x4, xn), to a confidence that the input belongs to a class—that is, f(x) =confidence(class). In the case of content/text classification, attributes are words or phrases or other domain-specific attributes derived from the words (e.g., parts of speech, presence of key terms), and the classes are categories of various kinds, such as for example important versus non-important content.

The content analyzer **130** accesses an abstraction layer **150** in connection with its analysis. The abstraction layer **150** provides for a content developer to specify content that is to be displayed at the recipient(s) **120** without requiring the developer to delineate what markup tags are employed by different browsers of the recipient devices **120**. In other words, the abstraction layer **150** provides for transparently mapping a set of high-level control instructions in connection with content rendering into lower level instructions implemented at the recipient device(s) for rendering of the content.

The invention provides for rendering of variable-sized pages of dynamic content based on UI characteristics of the recipient(s) **120**. The abstraction layer **150** accesses a device capabilities store **152** that holds parameters relating to capabilities (e.g., UI, processing . . .) of the recipient devices **120**. When a dynamically generated content (e.g., web page) is executed, objects in the content hierarchy are traversed to render markup for the appropriate device. The markup language may be HTML, cHTML, WML, etc., for example. The invention thus provides for automatically modifying (e.g., parsing, paginating, chunking, trimming, . . .) the content in a manner coincident with capabilities of the recipient device **120**.

More particularly, the content analyzer **130** processes a request for content from the recipient(s), identifies the type of recipient device as well as properties associated with the requested content. The abstraction layer **150** correlates the recipient device identification to capabilities associated with such device identification—the device type capabilities stored in the device capabilities store, for example. The abstraction layer **150** maps the particular content as well as developer preferences for content rendering with the device capabilities and provides the content analyzer **130** with a rendering scheme for providing the content to the recipient device **120**. A content distributor **140** facilitates dissemination and rendering of the content to/at the recipient devices **120**. As will be discussed in greater detail below, the content distributor **140** can also facilitate chunking the content into subsets for appropriate consumption by the recipient devices **120** in accordance with respective device capabilities. Therefore, the content does not need to be stored or cached at an intermediary device (e.g., at a server—which can be wasteful utilization of computing resources), but rather provided by the sender **110** in batches coincident with content consumption by the recipient device **120**.

It is to be appreciated that the content control system **102**, content analyzer **130**, classifier **132**, content distributor **140**, abstraction layer **150**, device capabilities store **152** can be components as that term is employed herein.

With reference to FIG. **2**, the following example illustrates developer programming in connection with the present invention. In this example, a Hello, World program creates a mobile Web Forms page with a single form on it—that form contains a Label control with the string: "Hello, Mobile World".

```
< %@ Page language="c#"
    Inherits="System.Web.UI.MobileControls.MobilePage" % >
< %@ Register TagPrefix="Mobile"
        Namespace="System.Web.UI.MobileControls"
            Assembly="System.Web.Mobile"%>
< mobile:Form id=Form1 runat="server" >
< mobile:Label id=Test Runat="Server" >
Hello, Mobile World< /mobile:Label >
< /mobile:Form >
```

As can be seen in FIG. **2**, the above code renders differently on respective devices **210** and **220**. The first device **210** is a cellular telephone running a wireless application protocol (WAP) browser that supports WML. The second device **220** is Pocket PC running an HTML browser. Via the abstraction layer **150** (FIG. **1**), mobile controls can be established that provide for generating customized markup for respective recipient devices **120**.

As noted above, the device capabilities store **152** holds information relating to capabilities of the recipient devices **120**. The store provides the content control system **102** with accurate information (e.g., display capabilities) of the recipient devices **120** to facilitate successful rendering of mobile controls. For example, mobile controls in connection with content rendering in accordance with the subject invention might require the following information regarding a particular recipient device **120**:

(a) markup language (e.g., HTML, cHTML, WML) associated with the device;

(b) type of browser employed by the device;

(c) number of display lines;

(d) cookie support;

(e) screen size.

Turning now to FIGS. **3** and **4**, it is to be appreciated that the content control system **102** of the subject invention can reside at a variety of locations. For example, the system **102** could reside at a server, or at a sending device/system **310** as depicted in FIG. **3**. Moreover, the system **102** could reside at recipient devices **420** as shown in FIG. **4** alone or in combination with also residing at a server and/or sending device. Moreover, the content control system **102** could reside in a distributed manner across a network of computing devices. In the event more than one content control system **102** is engaged in connection with rendering content on a particular device, any suitable protocol (e.g., master/slave, conflict resolution, arbitrating, collaboration) for governing meaningful rendering of the content can be employed.

FIG. **5** illustrates pagination of content in accordance with the present invention. Reference number **500** identifies a display associated with a device having capabilities for displaying a full amount of content as compared to the display **502** (shown in several states: **504**, **506**, **508**) of another device with limited capabilities as compared to the device of display **500**. The content control system **102** (FIG. **1**) of the invention provides for automatically breaking up the content into variable-sized content (e.g., web pages) appropriate for the requesting devices **500**, **502**. The entire content can be displayed on the screen of device **500**, while on the smaller device **502** with more limited capabilities, the content rendering appears as several pages comprising subsets of the original content. Navigation between the respective pages **504**,

506, **508** (via "Next" and "Previous" links) can be generated and managed automatically as discussed in greater detail below.

Turning now to FIG. **6**, it is to be appreciated that content can be set so as to have certain portions remain static (e.g., not modifiable) and other portions designated as being modifiable. Several pages **602** for displaying content on a particular device are illustrated with some static content (e.g., headers **650** and footers **660**) and modifiable content (e.g., list of prime numbers **670**). Accordingly, a developer can designate certain content (e.g., title, page number, next and previous page links) to appear on every generated web page (form). As can be seen, the static content **650**, **660** remains essentially consistent with respect to each generated page **610**, **620**, **630**; while the list of prime numbers is paginated in accordance with display capabilities (e.g., screen space) of the rendering device. However, it is to be appreciated that elements like the header **650** can be dynamically generated, but retain a static presence with respect to generated content. Additionally, elements such as the pager **660** can be introduced by the system in order to facilitate user interaction with modified content.

Below is exemplary code for carrying out such functionality in accordance with the present invention.

```
<%@ Page Inherits="System.Web.UI.MobileControls.MobilePage"
Language="VB" %>
<%@ Register TagPrefix="mobile"
Namespace="System.Web.UI.MobileControls"
Assembly="System.Web.Mobile" %>
<script runat="server" language="VB">
Protected Sub Page_Load(sender As Object, e As EventArgs)
    If(Not IsPostBack)
        ' Find all primes between 1 and 500, using a sieve and
        ' ignoring even numbers greater than 2.
        Dim item As new MobileListItem("2")
        Primes.Items.Add(item)
        Dim isCounted(501) As Boolean
        Dim i As Integer = 3
        Do While (i <= 500)
            If (isCounted(i) = False)
                Dim newItem As New MobileListItem(i.ToString( ))
                Primes.Items.Add(newItem)
                Dim multiple As Integer = i * 3
                Do While (multiple <= 500)
                    isCounted(multiple) = True
                    multiple = multiple + i * 2
                Loop
            End If
            i = i + 2
        Loop
    End If
End Sub
</script>
<mobile:Form runat="server" Paginate="true">
    <DeviceSpecific><Choice>
        <HeaderTemplate>
            <mobile:Label runat="server" StyleReference="title"
Text="Prime Numbers" />
        </HeaderTemplate>
    </Choice></Device Specific>
    <mobile:List runat="server" id="Primes" />
</mobile:Form>
```

FIG. **7** illustrates another aspect of the invention pertaining to optimization of content modification based on device capabilities. For example, some devices provide scrolling capabilities and thus content may be rendered in a more meaningful manner if rendered such that more content is exposed on a single web page than there is display space available. However, the scrolling option affords a user to view all content within a particular page via scrolling downwards or upwards. Regarding optimization, it is appreciated that for an extremely large content (e.g., 1000 prime numbers) scrolling on a single page becomes cumbersome and less valuable to a user. Accordingly, the subject invention provides for paginating content at a suitable place within the content taking into consideration whether scrolling functionality is available as well as available display space, etc.

Depending on the content, a developer may decide that certain controls should be grouped or paneled together in order to provide for meaningful rendering of content. Accordingly, the content control system **102** in connection with modification of the content can expose such grouped controls together (e.g., not split or modify) in accordance with the developer's preference for meaningful rendering of the content. Likewise, certain content may be entirely designated as not modifiable by the developer, and in such circumstance the content is rendered in its original form to the extent possible by the recipient device. **120**.

A pagination algorithm in accordance with the present invention, based on projected markup language for a particular page to be generated as well as device characteristics of a particular recipient device **120**, will determine where to delineate between respective controls of a tree of controls including delineation within a respective control. By such delineation determination, the pagination algorithm facilitates the content control system **102** rendering a sequence of pages on the recipient device(s) **120** that still retain the same functional value of an original form.

Moreover, it is to be appreciated that a variety of optimization schemes can be employed in connection with meaningful rendering of content. For example, the device store **152** (FIG. **1**) can store a variety of attributes (screen space, processing capabilities, display capabilities, available functions, etc.) associated with capabilities of the recipient device. The content analyzer **130** and abstraction layer **150** can optimize rendering of the content given the particular capabilities of the content and recipient device. Moreover, it is to be appreciated that user preferences can also be employed in connection with content rendering optimization. The type of content as well as user preferences for viewing the type of content can be considered as factors by the content control system **102** in connection with rendering the content.

In view of the exemplary systems shown and described above, methodologies that may be implemented in accordance with the present invention, will be better appreciated with reference to the flow charts of FIGS. **8** and **9**. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of blocks, it is to be understood and appreciated that the present invention is not limited by the order of the blocks, as some blocks may, in accordance with the present invention, occur in different orders and/or concurrently with other blocks from that shown and described herein. Moreover, not all illustrated blocks may be required to implement a methodology in accordance with the present invention.

The invention may be described in the general context of computer-executable instructions, such as program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Typically the functionality of the program modules may be combined or distributed as desired in various embodiments.

FIG. **8** illustrates a high-level flow diagram for modifying and/or rendering content in accordance with the subject invention. At **800**, a request is received to provide and/or disseminate dynamically generated content. Recipient devices for the content are identified as well as associated

capabilities (e.g., display constraints, processing capabilities) are identified at **810**. At **820**, a determination is made as to whether the content to be displayed in full exceeds display capabilities of the recipient device. If no, at **830**, the content is rendered. On the other hand, if at **820** a determination is made that the content exceeds device capabilities, the content is modified (e.g., sub-divided, paginated, truncated, compressed) into suitable subsets for rendering at the recipient device. At **850**, the subsets of content are sequentially rendered until all content is delivered.

It is to be appreciated that the present invention provides for various protocols with respect to rendering content and optimize utilization of computing resources. For example, in the event a particular content is of considerable size, a recipient device may request the content in batches coincident with consumption of the rendered content subset. Upon completion of a particular content subset, a next subset is requested and passed to the recipient device. Such protocol additionally optimizes resources of a server that may house a content control system in accordance with the subject invention. Rather than requiring the server to maintain all of the content to be rendered, the server can act as a proxy that governs pulling or requesting a next content subset from an originating device and passing the next content subset to the recipient device. Likewise, in the absence of a server running the content control system of the present invention as illustrated in FIGS. **3** and **4**, the client can also request subsets of content as a rate coincident with its rate of consumption of the content.

Turning now to FIG. **9**, one particular methodology for effecting modification of content in accordance with the subject invention is discussed. At **900**, content to be rendered (as well as modified prior to being rendered) is received. At **910**, optimal page weight for a recipient of the content is ascertained. Prior to modifying (e.g., paginating) the content, capabilities of the recipient device should be known. As discussed supra, such device capabilities can be stored in the device capabilities store **152** (FIG. **1**). Such device capability information can include a definition of optimum page weight, which is a limit of the amount of visible content that should be sent to the recipient device for a single viewable page. The optimal page weight can be for example a function of the number of lines considered appropriate for the recipient device **120**. For example, if the device can reasonably display ten lines of content, then the optimum page weight would be 1000 or 100 units per line. For a display with twice the number of vertical display lines, the optimal page weight would double to 2000. The number of units per line should remain consistent with the derivation when pagination occurs. More particularly, when an output from a control is being counted against such limit, the value of a single line should be consistent with the recipient device configuration.

As will be discussed, panel control and classes that derive from it (e.g., Form), can have a Boolean property for controlling whether or not the contents should be considered for pagination. When pagination occurs, if the Boolean is true, the contents are recursively considered and assigned a virtual page number. Thereafter, in a rendering phase, a virtual page is selected for display. The render methodology associated with each control in an active form is called and will emit content, if and when, the respective virtual page assignment corresponds to the current virtual page.

Thus, after the optimal page weight is ascertained at **910**, a determination is made at **920** if the total content weight exceeds the optimal page weight. If no, at **924** the content is rendered. If at **920**, it is determined that the total content weight exceeds the optimal page weight at **930** controls are assigned to virtual pageN+1 (N starting at 0). As noted above, if the virtual page assignment for the control corresponds to the current virtual page the content relating to the control is rendered. At **940**, if the remaining content weight is less than X (the minimal weight required to display a single control) the content is displayed as a last display page. If the remaining content weight >X, the count with respect to virtual page assignment is incremented by one. At **970**, a determination is made as to whether all content has been displayed. If no, the methodology returns to **930**—if yes, the methodology returns to **900**.

In order to provide more content for understanding the above methodology, we return to the example where the optimal page weight is 2000. When pagination begins, the optimal page weight is ascertained—other variables are initialized for the process as well. The remaining weight is equal to the optimum page weight and the virtual page is set to 1. Suppose that the optimal page weight for the requesting browser is 2000, and then the remaining weight is initially 2000. The calculation for the respective form control itself does not affect the remaining weight as it does not produce visible content. Each child of the control is considered in turn and the variables are affected by the value reported by the control. For this example, each label simply counts as 1 visible line, or 100 points against the limit. As each control is considered, the remaining weight is reduced for that control and the virtual page is assigned to the control. At the end of 17 labels, the remaining weight would be 300 and each control would have a virtual page of 1.

Considering a second example display with a device having an optimum page weight of 700, the first seven controls would be assigned a virtual page of 1, but then the remaining weight has been reduced to 0. The next control can therefore not be assigned to that virtual page as it would make the combined total of the virtual page exceed the configured optimum value. Accordingly, the remaining weight is reset to the optimum page weight of 700, and the virtual page is incremented to 2. The next seven controls are then assigned to virtual page 2 as again the remaining weight is again reduced to 0. The remaining weight is again reset to the optimum value and the virtual page is incremented to the assign the last three controls to virtual page 3. When the browser first requests the page, the current page is set to 1. When the controls are rendered, they only display content if their virtual page corresponds to the current page. Thus, the first seven controls are displayed. Additionally, a "pager" is rendered to allow the user to request the next virtual page. When the user follows the "Next" link, the current page is set to 2, the pagination occurs again as part of the page processing, and all controls with the corresponding virtual page rendered content.

It is to be appreciated that the methodology of FIG. **9** can be applied to clustered or grouped sets of controls as well. In particular, a developer may desire to have a subset of controls rendered concurrently in order to provide for meaningful rendering of the original content. Thus, the optimal page weight can be compared against a weight associated with the entire subset alone or in conjunction with other subsets in connection with rendering thereof on a recipient device **120**. It is also to be appreciated that the weights of the controls can be dependent upon the type of recipient device. For example, an adapter can be employed to assign a weight to a control given various device and control characteristics such as for example the markup language being employed. Thus, the control weights can be variant and assigned different weights corresponding to state of execution, for example.

The present invention also provides for other functionality to facilitate enabling a developer to exploit the invention. For example, a page can expose a "Control to Paginate" property

that allows pagination to be off in general, but to be programmatically asserted so that a subset of controls can be carried across multiple pages. The controls can also expose a paginated event that is executed when the pagination occurs so that function delegates can customize output. Furthermore, custom pagination can allow a developer to specify a fixed number of items to be displayed per page, regardless of capabilities of the requesting device.

FIG. **10** illustrates another aspect of the subject invention which provides for a system, **1000** that manipulates content in connection with display and processing capabilities of receiving devices. A sender **1010** provides content to be rendered at various recipient devices **1030** and **1050**. Recipient device **1030** has significant display and processing capabilities while device **1050** has limited capabilities as compared to device **1030**. The content to be rendered relates to a web page conveying information relating to a Monday car sale by AutoLand. The content control system **1020** analyzes the content against respective capabilities of the devices **1030** and **1050** and modifies the content for rendering on each device in accordance with the device capabilities. As can be seen since the device **1030** has greater capabilities the content was only slight modified and rendered in at or close to original form—thus a picture of a car is also rendered in the display area **1040** of the device. Device **1050** on the other hand has limited capabilities and thus the content control system **1020** modified the content so that the picture of the automobile is not rendered in the display area **1060** of the device, but the meaningful information "AutoLane car sale this Monday" is displayed.

In order to provide additional context for various aspects of the present invention, FIG. **11** and the following discussion are intended to provide a brief, general description of a suitable operating environment **1110** in which various aspects of the present invention may be implemented. FIG. **11** provides an additional and/or alternative operating environment in which the present invention can operate. While the invention is described in the general context of computer-executable instructions, such as program modules, executed by one or more computers or other devices, those skilled in the art will recognize that the invention can also be implemented in combination with other program modules and/or as a combination of hardware and software. Generally, however, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular data types. The operating environment **1110** is only one example of a suitable operating environment and is not intended to suggest any limitation as to the scope of use or functionality of the invention. Other well known computer systems, environments, and/or configurations that may be suitable for use with the invention include but are not limited to, personal computers, hand-held or laptop devices, multiprocessor systems, microprocessor-based systems, programmable consumer electronics, network PCs, minicomputers, mainframe computers, distributed computing environments that include the above systems or devices, and the like.

With reference to FIG. **11**, an exemplary environment **1110** for implementing various aspects of the invention includes a computer **1112**. The computer **1112** includes a processing unit **1114**, a system memory **1116**, and a system bus **1118**. The system bus **1118** couples system components including, but not limited to, the system memory **1116** to the processing unit **1114**. The processing unit **1114** can be any of various available processors. Dual microprocessors and other multiprocessor architectures also can be employed as the processing unit **1114**.

The system bus **1118** can be any of several types of bus structure(s) including the memory bus or memory controller, a peripheral bus or external bus, and/or a local bus using any variety of available bus architectures including, but not limited to, 11-bit bus, Industrial Standard Architecture (ISA), Micro-Channel Architecture (MSA), Extended ISA (EISA), Intelligent Drive Electronics (IDE), VESA Local Bus (VLB), Peripheral Component Interconnect (PCI), Universal Serial Bus (USB), Advanced Graphics Port (AGP), Personal Computer Memory Card International Association bus (PCMCIA), and Small Computer Systems Interface (SCSI).

The system memory **1116** includes volatile memory **1120** and nonvolatile memory **1122**. The basic input/output system (BIOS), containing the basic routines to transfer information between elements within the computer **1112**, such as during start-up, is stored in nonvolatile memory **1122**. By way of illustration, and not limitation, nonvolatile memory **1122** can include read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash memory. Volatile memory **1120** includes random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM).

Computer **1112** also includes removable/nonremovable, volatile/nonvolatile computer storage media. FIG. **11** illustrates, for example a disk storage **1124**. Disk storage **1124** includes, but is not limited to, devices like a magnetic disk drive, floppy disk drive, tape drive, Jazz drive, Zip drive, LS-100 drive, flash memory card, or memory stick. In addition, disk storage **1124** can include storage media separately or in combination with other storage media including but not limited to an optical disk drive such as a compact disk ROM device (CD-ROM), CD recordable drive (CD-R Drive), CD rewritable drive (CD-RW Drive) or a digital versatile disk ROM drive (DVD-ROM). To facilitate connection of the disk storage devices **1124** to the system bus **1118**, a removable or non-removable interface is typically used such as interface **1126**.

It is to be appreciated that FIG. **11** describes software that acts as an intermediary between users and the basic computer resources described in suitable operating environment **1110**. Such software includes an operating system **1128**. The operating system **1128**, which can be stored on disk storage **1124**, acts to control and allocate resources of the computer system **1112**. System applications **1130** take advantage of the management of resources by the operating system **1128** through program modules **1132** and program data **1134** stored either in system memory **1116** or on disk storage **1124**. It is to be appreciated that the present invention can be implemented with various operating systems or combinations of operating systems.

A user enters commands or information into the computer **1112** through input device(s) **1136**. Input devices **1136** include, but are not limited to, a pointing device such as a mouse, trackball, stylus, touch pad, keyboard, microphone, joystick, game pad, satellite dish, scanner, TV tuner card, digital camera, digital video camera, web camera, and the like. These and other input devices connect to the processing unit **1114** through the system bus **1118** via interface port(s) **1138**. Interface port(s) **1138** include, for example, a serial port, a parallel port, a game port, and a universal serial bus (USB). Output device(s) **1140** use some of the same type of ports as input device(s) **1136**. Thus, for example, a USB port

may be used to provide input to computer **1112**, and to output information from computer **1112** to an output device **1140**. Output adapter **1142** is provided to illustrate that there are some output devices **1140** like monitors, speakers, and printers among other output devices **1140** that require special adapters. The output adapters **1142** include, by way of illustration and not limitation, video and sound cards that provide a means of connection between the output device **1140** and the system bus **1118**. It should be noted that other devices and/or systems of devices provide both input and output capabilities such as remote computer(s) **1144**.

Computer **1112** can operate in a networked environment using logical connections to one or more remote computers, such as remote computer **1144**. The remote computer **1144** can be a personal computer, a server, a router, a network PC, a workstation, a microprocessor based appliance, a peer device or other common network node and the like, and typically includes many or all of the elements described relative to computer **1112**. For purposes of brevity, only a memory storage device **1146** is illustrated with remote computer **1144**. Remote computer **1144** is logically connected to computer **1112** through a network interface **1148** and then physically connected via communication connection **1150**. Network interface **1148** encompasses communication networks such as local-area networks (LAN) and wide-area networks (WAN). LAN technologies include Fiber Distributed Data Interface (FDDI), Copper Distributed Data Interface (CDDI), Ethernet/IEEE 1102.3, Token Ring/IEEE 1102.5 and the like. WAN technologies include, but are not limited to, point-to-point links, circuit switching networks like Integrated Services Digital Networks (ISDN) and variations thereon, packet switching networks, and Digital Subscriber Lines (DSL).

Communication connection(s) **1150** refers to the hardware/software employed to connect the network interface **1148** to the bus **1118**. While communication connection **1150** is shown for illustrative clarity inside computer **1112**, it can also be external to computer **1112**. The hardware/software necessary for connection to the network interface **1148** includes, for exemplary purposes only, internal and external technologies such as, modems including regular telephone grade modems, cable modems and DSL modems, ISDN adapters, and Ethernet cards.

FIG. **12** is a schematic block diagram of a sample computing environment **1200** with which the present invention can interact. The system **1200** includes one or more client(s) **1210**. The client(s) **1210** can be hardware and/or software (e.g., threads, processes, computing devices). The system **1200** also includes one or more server(s) **1230**. The server(s) **1230** can also be hardware and/or software (e.g., threads, processes, computing devices). The servers **1230** can house threads to perform transformations by employing the present invention, for example. One possible communication between a client **1210** and a server **1230** may be in the form of a data packet adapted to be transmitted between two or more computer processes. The system **1200** includes a communication framework **1250** that can be employed to facilitate communications between the client(s) **1210** and the server(s) **1230**. The client(s) **1210** are operably connected to one or more client data store(s) **1260** that can be employed to store information local to the client(s) **1210**. Similarly, the server(s) **1230** are operably connected to one or more server data store(s) **1240** that can be employed to store information local to the servers **1230**.

It is appreciated that the systems and methods described herein can be utilized with a variety of suitable components (e.g., software and/or hardware) and devices and still be in accordance with the present invention. Suitable components and devices include MP3 players, DVD players, portable DVD players, CD players, portable CD players, video compact disk (VCD) players, super video compact disk (SVCD) players, electronic book devices, personal digital assistants (PDA), computers, car stereos, portable telephones and the like.

What has been described above includes examples of the present invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present invention, but one of ordinary skill in the art may recognize that many further combinations and permutations of the present invention are possible. Accordingly, the present invention is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A computer implemented system for rendering of dynamically generated content, comprising:

an analysis component that compares content to be rendered at a recipient device against a plurality of capabilities of the device, determines static content portions and modifiable content portions of the dynamically generated content, and modifies the modifiable portions of the dynamically generated content in accordance to the comparison, the plurality of capabilities including at least the device's processor and display constraints; and

a distribution component that distributes modified dynamically generated content to the recipient device.

2. The system of claim **1**, further comprising a device capabilities store that holds information relating to capabilities of recipient devices.

3. The system of claim **2**, the capabilities including at least one of: the device's processing unit, display space, display capabilities, cookie handling capabilities, mark up language employed and web browser employed.

4. The system of claim **1**, further comprising an abstraction layer that maps content characteristics with capabilities of the recipient device.

5. The system of claim **1**, the content modification comprising at least one of pagination of the content, chunking of the content, truncating of the content, trimming of the content, or coincident with a markup language suitable for the recipient device, or any combination thereof.

6. The system of claim **1**, the distributor component providing the content in subsets coincident with content consumption capabilities of the recipient device.

7. The system of claim **1**, the further having one or more controls indicating one or more subset of content that are not to be modified.

8. The system of claim **1**, the analysis component optimizing content modification based at least in part on determining that the recipient device has scrolling capabilities.

9. The system of claim **1**, further having one or more controls identifying a subset of content that is to be rendered together.

10. The system of claim **1**, further having one or more controls identifying a user-defined process to be executed upon a determination that content is to be modified.

11. A computer implemented method for rendering dynamically generated content, comprising:

determining static content portions and modifiable content portions of the dynamically generated content;

comparing the dynamically generated content to be rendered at a receiving device against a plurality of capabilities of the receiving device, the capabilities of the receiving device including at least capabilities of the receiving device's processor and display constraints; and

modifying the modifiable content portions of the dynamically generated content for suitable rendering on the receiving device based upon the receiving device's capabilities.

12. The method of claim **11** further comprising identifying the recipient device's capabilities.

13. The method of claim **11** further comprising dividing the content into subsets suitable for rendering on the receiving device.

14. The method of claim **13** further comprising rendering the subsets sequentially in accordance with consumption capabilities of the receiving device.

15. The method of claim **11** further comprising identifying subsets of content that must be rendered together.

16. The method of claim **11** further comprising ascertaining an optimal page weight relating to content rendering by the receiving device.

17. The method of claim **16** further comprising comparing total content weight to the optimal page weight for the receiving device, and rendering subsets of the content in accordance with the comparison.

18. The method of claim **17** further comprising executing a user-defined process associated with a control.

19. The method of claim **11** further comprising assigning controls for rendering the content, and displaying the content in accordance with the controls.

* * * * *